

A NATIONAL PRIORITY



Marine & Aquatic Science Literacy: Educating the 21st-Century Workforce



A Report from the National Sea Grant Network

Sea Grant



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Marine and Aquatic Science Literacy: Educating the 21st-Century Workforce was developed by the Marine and Aquatic Science Literacy Theme Team of the Sea Grant Association for distribution throughout the National Sea Grant Network and for promoting the support of the research and outreach needs identified and described herein. We gratefully acknowledge the contributions of every Sea Grant program to this document. More information on Sea Grant's Theme Teams is available on the National Sea Grant Web site at <http://www.seagrants.noaa.gov/>.

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A National Priority

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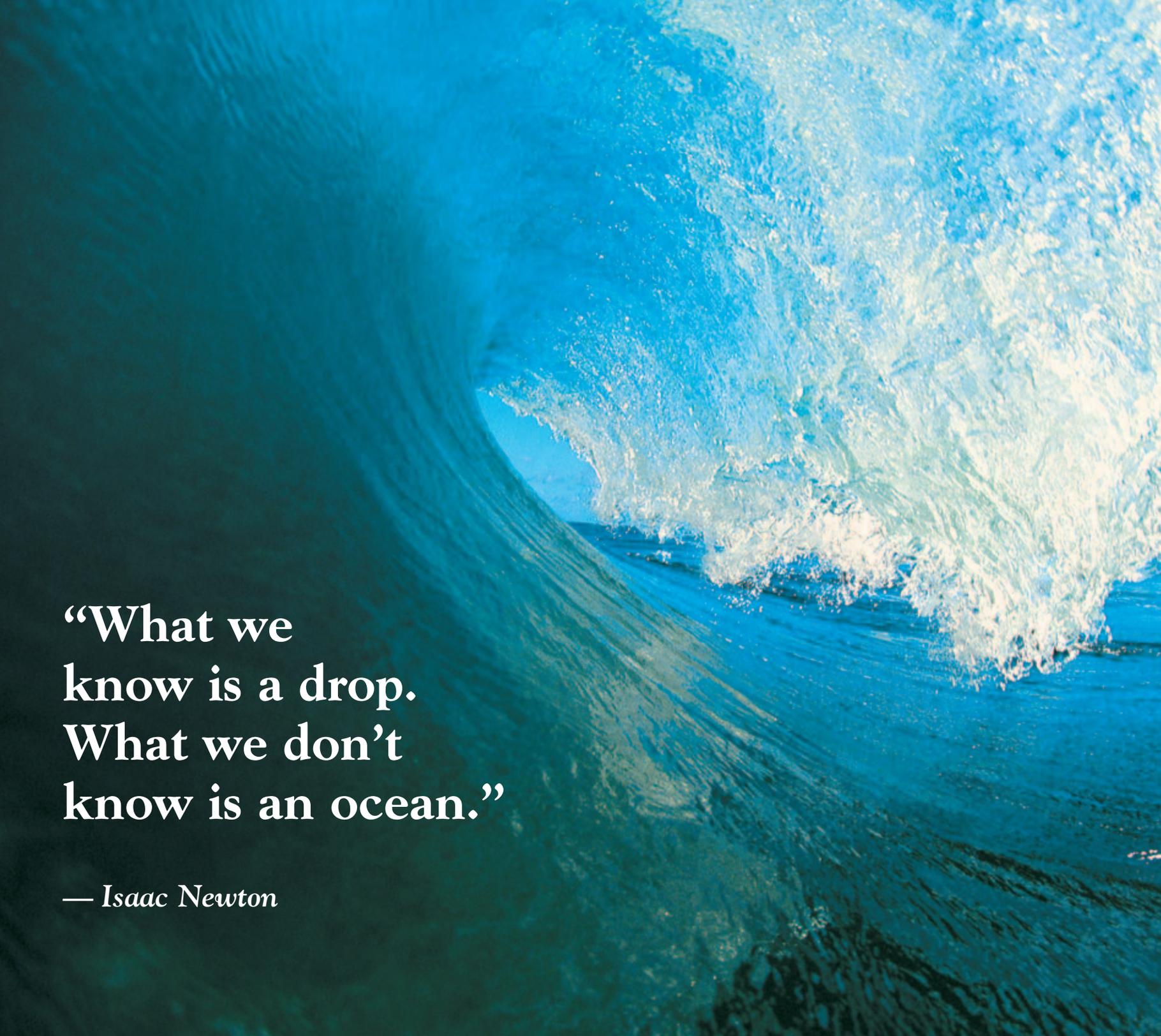


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A large, curling blue wave with white foam crashing over the side of a boat. The water is a deep, vibrant blue, and the foam is bright white, creating a dramatic contrast. The wave is captured in a dynamic, almost tunnel-like perspective, suggesting the viewer is on the boat looking out at the sea.

**“What we
know is a drop.
What we don’t
know is an ocean.”**

— Isaac Newton



Introduction

No matter where you live, the ocean affects your life every day. It is the world's great weather maker and a major provider of food. It is the chief conduit for global commerce, transporting over 2 billion tons of products to Americans per year. It is heralded as the 21st century's treasure chest for new pharmaceuticals. It's also an endless source of recreation, fascination, and awe. Yet we know less about this resource that covers over 70% of our planet than we do about the moon (Grace 1997).

The challenges to marine and aquatic science education in this country are profound. Fifty-two million pre-college students are being taught science by 1.9 million elementary and 186,000 middle- and high-school teachers. Of these educators, 37% in high school, 83% in middle school, and practically all teaching science at the elementary level lack science degrees (NSTA 2000). To compound this problem, too few of the teachers who do have science degrees have studied marine and aquatic science. In fact, these content areas are barely mentioned in the *National Science Education Standards*, an influential report released by the National Research Council in 1996.

Over the last two decades, science education literature has continually called for education reform. Specifically, the landmark studies *A Nation At Risk* (Dept. of Education 1983), *Educating Americans for the 21st Century* (National Science Board 1983), *The National Science Foundation Survey Report* (1988), the *Third International Math and Science Study* (IEA 1996), and the *Third International Math and Science Study-Repeated* (IEA 1999), have all reinforced our nation's awareness of this reality: students graduating from our public schools, when compared to those educated in many other countries, are not competitive in math and science.

So as our country is challenged with dramatically improving its overall grade in math and science education, Sea Grant's theme team for marine and aquatic science literacy has set the following goal: to promote widespread and varied opportunities for both educators and citizens of all ages to acquire an understanding of a range of issues related to marine and aquatic science. Sea Grant is uniquely positioned to bring marine and aquatic science literacy to the entire U.S. population, beginning with pre-school students and continuing through lifelong learners.



▲ Sea Grant provides educational opportunities in marine and aquatic science for people of all ages.

“The future of this nation depends on setting a primary goal of having a strong, competitive science and engineering workforce and a citizenry equipped to function in a complex world.

And, to achieve this goal, educational excellence in math and science education at all levels should enhance every American’s life opportunities . . . [fostering] productive employment, active citizenship, and lifelong learning.”

— *The National Science Board, 1999*



Addressing Marine and Aquatic Issues in Times of Change

In the year 2000, the United States Commission on National Security/21st Century documented its view that improved math and science education is a national security issue. Soon after, President Bush responded by unveiling his vision for strengthened education standards in the No Child Left Behind Act of 2001.

It states that in consideration of poor performance by U.S. students in the areas of math and science, three problems must be addressed: (1) too many teachers are teaching “out of his/her field”; (2) too few students are enrolling in advanced course work; and (3) too few schools offer textbooks and curricula

that are challenging. President Bush’s education reform agenda also recommended that partnerships form between the pre-K–12 community and the scientists, mathematicians, and engineers of institutions of higher learning to improve teacher training and classroom opportunities in these areas for the benefit of all children.

Many educators and scientists agree that engaging students in inquiry-based authentic science is critical to improving mathematics and science learning. Fitting perfectly into that formula for success are the marine and aquatic sciences, which provide a particularly engaging platform from which nearly

The marine and aquatic sciences provide an engaging platform from which nearly all science concepts can be taught. ►



SEA FACT: The ocean covers over 70% of the Earth’s surface, yet less than 5% of the seafloor has been mapped.

all science concepts recommended in the *National Science Education Standards* (1996) can be taught.

High-level advocates for improved marine and aquatic science education are becoming increasingly vocal and proactive. Over the past three years, several efforts have been launched at the national level that address issues identified as high priority by the marine and aquatic science education community. Both educators and scientists from a variety of disciplines, agencies, and institutions offer remarkably similar perspectives on marine and aquatic science education in the following recent reports and program startups: the Consortium for Oceanographic Research and Education's White Paper on Ocean Science Education, the National Science Foundation's Centers for Ocean Sciences Education Excellence (COSEE) initiative, the National Oceanographic Partnership Program's Strategy for Ocean Science Education, and the National Marine Educators Association's recommendations to the United States Commission on Ocean Policy and the Pew Ocean Commission.

Though the concerns are many, there are also a number of common themes expressed in these efforts. It is clear that a unified voice has emerged from leaders representing all sectors of marine and aquatic science education.



▲ *Sea Grant educators offer students and their teachers a broad variety of field, laboratory, and classroom experiences to increase their knowledge of the world of water.*

For example, experts agree that an increase in public knowledge and understanding of the scientific processes and issues related to marine and aquatic areas is critical. Improving marine and aquatic science literacy calls for more than just public exposure and awareness efforts. Literacy requires citizens to have enough understanding of the science and issues related to marine and aquatic areas that they are able to communicate this information to others.

One area of critical need is increased collaboration between the education and scientific communities. Working scientists are not only in a position to provide content and materials for classrooms, they also can share personal

experiences and offer special opportunities to teachers, their students, and the public, such as lab tours or site visits. Scientists are best able to demonstrate how real science is done and to model how scientific data are used.

Also, in order for authentic marine and aquatic science education to become commonplace in today's K–12 schools, the important concepts and processes must be linked to both the national and state science education standards across the country. These education standards form the backbone for teacher accountability and student assessment in most of the United States. In addition, incorporating marine and aquatic science education into the academic

training and professional development of those seeking teaching degrees or already working in schools or informal learning environments such as aquaria and museums is critical to increasing public literacy about ocean and coastal issues and resources.

Interwoven in all of the previously mentioned needs is the imperative that marine and aquatic science literacy efforts reach out to all Americans — including African Americans, Hispanics/Latinos, Asian Americans, Native Americans, women of all ethnicities, and other historically under-represented population groups. At a minimum, such groups should be offered opportunities to increase their marine and aquatic science literacy in ways that are culturally relevant and that make a career in aquatic sciences a viable alternative for any student.

In order for these critical needs to be adequately addressed, coordinated and sustained federal funding must be committed to support already successful programs and to provide support for new initiatives. Many of these efforts cannot be accomplished on a short one- to two-year time scale. Improved marine and aquatic science literacy is only effectively measured on a five- to ten-year scale, and programs that stop and start, or have a short duration, have far less lasting value.

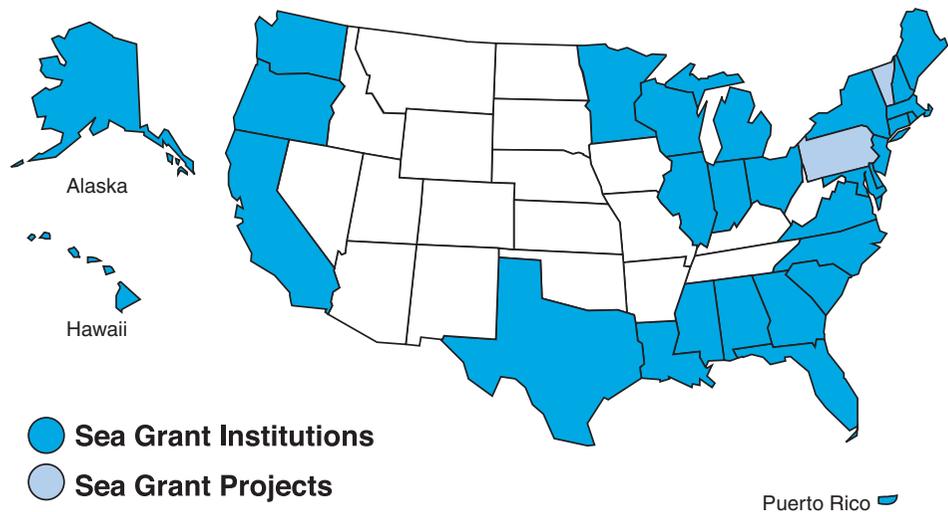


Resources Needed

At present, the Sea Grant network has an education contact in each of its 30 local programs. However, the Sea Grant Education Network (SGEN) comprises no more than the equivalent of 20 full-time educators across all 30 Sea Grant programs. Even with this very small workforce, the SGEN is the oldest network of coastal and marine educators in the country. Expertise within our ranks is unmatched. In addition to leading a wide range of local activities, many individuals in the SGEN are regularly sought — as highly respected leaders in marine and aquatic science education —

to participate in activities that have a broader, national impact.

Sea Grant's Marine and Aquatic Science Literacy Theme Team agrees that significant additional resources are needed in order for the SGEN to begin addressing the increasingly recognized marine and aquatic science literacy needs of this nation. At a minimum, there should be at least one full-time person in each Sea Grant program dedicated to marine and aquatic science education. These individuals should have at least a master's degree in education and/or aquatic science (or a closely related field), enabling



▲ While there are 30 Sea Grant programs across the United States, the Sea Grant Education Network (SGEN) comprises no more than the equivalent of 20 full-time educators.

SEA FACT: The Great Lakes contain one-fifth of the world's fresh surface water — that's 6 quadrillion gallons!

them to provide professional expertise in both science and education.

Significant fiscal support also should be provided for these individuals to develop and sustain programming appropriate for their local constituencies and Sea Grant. This would require approximately \$200,000 for each of the 30 Sea Grant programs, or \$6 million for the entire Sea Grant network. In addition, \$5 million should be offered annually through grants for projects and research that target national and regional marine and aquatic science literacy. Those projects funded would be partnership-based, scientifically credible, and educationally exemplary.

Finally, \$5 million should be made available to the National Sea Grant Program Office to support educational partnerships with other entities such as the National Oceanographic Partnership Program, the National Science Foundation, and other agencies and non-profit organizations that specifically provide opportunities to the Sea Grant network. The total recommended initial investment is \$16 million per year for a minimum of 10 years.

The following pages highlight the eight major objectives that would be targeted with this increased investment and provide examples of Sea Grant's current successes in marine and aquatic science education.

INVESTING IN MARINE AND AQUATIC SCIENCE EDUCATION: RECOMMENDATIONS AND INITIATIVES FOR SEA GRANT

WHAT SEA GRANT NEEDS:

-  **Sustained, increased investment of \$16 million per year (annually adjusted for inflation) for marine and aquatic science education for a minimum of 10 years.**
-  **Elevated status of education — to equal standing with research and outreach — in advancing Sea Grant's mission.**
 - ◆ Every Sea Grant program should have at least one full-time person dedicated to marine and aquatic science education. These individuals should have at least a master's degree in education, aquatic science, or a closely related field.
 - ◆ \$200,000 should be provided to each Sea Grant program, or \$6 million for the 30-program network, to develop and sustain education programs.
 - ◆ \$5 million in grants should be offered annually for exemplary partnership projects that target national and regional marine and aquatic science literacy.
 - ◆ \$5 million should be made available to the National Sea Grant Program to support educational partnerships with such entities as the National Oceanographic Partnership Program, the National Science Foundation, and others.

WHAT SEA GRANT CAN DELIVER:

-  **The Sea Grant Education Network would channel an increased investment into the following eight objectives to improve marine and aquatic science literacy:**
 - ◆ Develop expanded professional development programs for future teachers, as well as in-service activities for professional educators.
 - ◆ Design hands-on formal and informal education programs in marine and aquatic science that are innovative and effective.
 - ◆ Create new research and education opportunities in marine and aquatic science for undergraduate and graduate students.
 - ◆ Produce high-quality marine and aquatic curricula and educational materials based on sound science.
 - ◆ Foster increased education of traditionally underrepresented and underserved groups in marine and aquatic science.
 - ◆ Expand education and training in the effective use of information technology.
 - ◆ Provide formative and summative evaluations of Sea Grant education programs.
 - ◆ Serve in a leadership role to create or strengthen existing collaborations and partnerships in marine and aquatic science education.



Professional Development for Educators

SEA GRANT EDUCATORS ARE UNIQUELY POSITIONED TO...

- ... *Produce high-quality materials, curricula, and programs based on national and state standards.*
- ... *Continue as national leaders in providing exemplary, science-based teacher preparation and professional development opportunities on a wide range of topics.*

Sea Grant has a long history of assisting teachers. This has been accomplished largely by providing classroom materials and by offering professional development programs in marine and aquatic science education for future teachers, as well as professional educators.

Sea Grant educators typically have academic preparation in both science and teaching. In fact, most have advanced science degrees plus formal or informal teaching experience. Moreover, all Sea Grant educators are associated with universities or research institutions through courtesy appointments or full academic rank. The professional background of Sea Grant educators, combined with their access to the expertise of an interactive network of scientists, coastal field agents, writers, editors, artists, and media specialists, results in a team of educators unequalled in their ability to obtain and deliver marine and aquatic science information.

Sea Grant emphasized K–12 education early in its own history when, in the 1970s and mid-1980s, it developed and distributed curricula through professional development programs for teachers. Although many of these early curricula focused on topics of narrow, regional interest, the SGEN continues to heighten teachers' knowledge of science, enhance their instructional skills, and provide high-quality curricula for educating students about watersheds, coastal processes, and ocean sciences and their relevance to our daily lives and future. More recently, the SGEN has initiated teacher education projects that have addressed specific topics such as invasive species, climate change, and other global environmental issues.

Because of the fast-moving discoveries in science today, teachers need regular professional development opportunities to remain current



▲ Teachers and scientists work together on oceanographic research in the COSEE-Central Gulf of Mexico Summer Institute sponsored by NOAA Sea Grant, the National Science Foundation, and the Office of Naval Research.

in their knowledge base. In addition, each year, teachers retire or move on to other careers, so there is a continuous need for more teachers, who also require professional development opportunities. Sea Grant's ability to significantly address this need is not limited by the absence of professional development programs for teachers, but by the minimal allocation of resources to devote to this purpose. The multiplier effect of educating teachers, who in turn, educate many students, makes increased funding of teacher professional development a wise investment.

SEA FACT: An estimated 350 species of non-native plants and animals have been introduced to U.S. waters.

■ Aquatic Invasive Species (AIS) can threaten native plants and animals and cause major economic problems for water users, from industries to homeowners. “Aquatics on the Move” is one of Sea Grant’s national strategic initiatives in education. Sea Grant programs in Illinois-Indiana, Louisiana, Minnesota, New York, Ohio, and Washington hosted the first standards-based AIS workshops in geography in partnership with geographic alliances in each state. Seventy-seven teachers from five states learned about zebra mussels and other aquatic invaders from Sea Grant researchers and outreach specialists. The teachers then developed 29 new classroom lessons that are now aligned with the *National Geography Education Standards* and are available on CD-ROM. They have also brought their hands-on experience into their classrooms, using interactive education products and hundreds of free instructional materials that detail the origin, distribution, spread, and impact of exotic aquatic species. To date, over 5,000 students have learned how they can be involved in helping to prevent the spread of AIS.

■ The University of Georgia’s Marine Extension Service Education Center and Aquarium on Skidaway Island outside Savannah is the site of a unique educational program. Now in its 14th year, the program, which is funded by Georgia Sea Grant, runs for 50 weeks and is designed to provide on-the-job experience for prospective marine educators. Applicants have come from as far away as England to participate in this exciting opportunity. After an initial three-month training period, interns assume teaching roles under the supervision of Marine

Extension educators. The interns additionally have specific areas of focus such as helping to produce programs for Georgia’s long-distance learning center, helping maintain the aquarium, and assisting with scheduling the many visits by school groups and Elderhostels. The program’s effectiveness is evident in the career choices of past participants.

■ The Sea Grant-supported COASTeam science education program has trained more than 300 elementary and middle-school teachers from 12 counties in South Carolina. COASTeam is designed to meet the needs of South Carolina teachers for standards-based, multidisciplinary science programs. At least 5,000 South Carolina students benefit annually from the improved instructional skills of the teachers, while curricula based on state standards are now being developed for educators at the South Carolina Aquarium.

■ Several teacher-education credit courses, which began as Sea Grant workshops in Ohio, have become institutionalized so that continued funding now comes from Ohio State University. These courses include a Great Lakes Education Workshop, Marine and Aquatic Education, and Global Change Education.



▲ Teachers work on global change curriculum activities in a summer workshop hosted by NOAA Sea Grant, the National Science Foundation, and the Office of Naval Research.

■ The word “summertime” often conjures up images of lazy afternoons sipping iced tea on the porch, but participants in the Sea Grant Teacher Intern program sponsored recently by Connecticut Sea Grant at the Maritime Aquarium in Norwalk had other things to do. The four-week, paid internships provided teachers with a unique professional development opportunity combining research, field experiences, and aquarium work. Interns investigated salt-marsh reclamation programs and water-quality analyses, commercial fishing, water treatment, animal feeding and tank maintenance, and curriculum development, with the assistance of state and city agencies, industry, and the aquarium staff.



Formal and Informal Education Efforts

SEA GRANT EDUCATORS ARE UNIQUELY POSITIONED TO...

- ... Continue providing exemplary, science-based programming to engage audiences of all ages.
- ... Develop and produce high-quality exhibits and resource materials.
- ... Remain leaders in delivering the latest research-based information through a broad variety of programs.

From volunteer water-quality monitoring programs to festivals and fishing rodeos, Sea Grant educators have been developing and implementing successful inquiry-based formal and informal programs for nearly four decades, reaching learners ranging in age from kindergartners to senior citizens. In order to better use time, money, and personnel, the SGEN devotes significant effort and resources each year to initiate joint programs with partners at the state, regional, and national levels who have similar missions.

These programs are designed to engage the participants and ultimately help them become better stewards of the environment. Teaching formats vary greatly. For example, one program may provide a detailed hands-on laboratory experience to identify common marine microbes in coastal waters, while another may offer an overview of the latest developments in harmful algal bloom research featuring scientific experts.

Sea Grant educators, working closely with marine scientists and communications specialists, have tremendous capabilities in connecting with people from all walks of life and sparking their interest in, understanding, and appreciation of coastal resources. Those capabilities can be multiplied through more school and family programs, summer camps, environmental monitoring programs, mentoring programs, publications, radio series, festivals, traveling exhibits, media events, workshops, public lectures, symposia, courses, videos, and virtual field trips and other distance learning programs. However, current funding seriously limits this potential. While partnering with other sponsors is a partial solution, often such partnerships result in dilution of content to accommodate the needs of the partner. Additional investment would help realize the full potential existent in the Sea Grant network.



▲ Sea Grant educators have tremendous capabilities to spark youngsters' interest in marine and aquatic resources, as this science lab demonstrates.

SEA FACT: Coral reefs colonize a mere one percent of the Earth's surface, yet they are home to one-quarter of all marine life.

■ Seventeen middle- and high-school classrooms across southern Louisiana are now involved in Coastal Roots, a year-round program designed to teach students about coastal erosion and wetlands restoration. Students are responsible for managing all aspects of a plant nursery at their school. For one year, beginning in January, students germinate and maintain nearly 1,000 native seedlings in their nurseries. During the fall, these students plant their seedlings at a site along the coast needing habitat restoration.

■ Sea Grant's ReefTeach and ReefWatchers programs are helping ocean users become better stewards of Hawaii's coral reefs. ReefTeach teaches volunteers, from grade-school age to adult, about coral reef ecology. These volunteers then teach swimmers and snorkelers about the importance of corals and reefs and the effects of trampling. ReefWatchers consists of volunteers, from high-school age to adult, who are taught to monitor specific sites and perform fish counts and intertidal surveys as an aid to state fisheries resource management.

■ For over 20 years, volunteers with the University of New Hampshire's Marine Docent Program have been presenting marine programs to school and civic groups in the region, offering tours of the university's marine labs, and leading boat and field trips. The 180 docents, trained and organized by Sea Grant, travel some 50,000 miles a year, bringing "Sea Trek" programs on global climate change to marine careers to 15,000 people in New Hampshire, northern Massachusetts, and southern Maine. In 2003, the program was recognized nationally for best management practices.



▲ Students involved in Sea Grant's Coastal Roots program plant native seedlings at a site needing habitat restoration.

■ The University of Delaware's Coast Day, organized by Sea Grant, has been called the "Superbowl of marine education events." Held every first Sunday in October since 1977 at the Lewes campus, Coast Day immerses over 10,000 visitors in activities ranging from sea seminars, exhibits, ship tours, and research demonstrations, to crab races and a seafood chowder challenge. In a recent survey, over 98% of visitors said they left Coast Day with a greater understanding and appreciation of marine resources. The event has earned state and national honors for environmental education. It also has spawned Coast Days in Maryland, New Jersey, Pennsylvania, and Oregon.

■ Wisconsin Sea Grant's "Earthwatch" is the longest-running program on science and the environment on radio today. Conceived shortly after the first Earth Day in 1970, and produced with support from the Gaylord Nelson Institute for Environmental Studies,

Earthwatch also provides employment and professional science-writing experience for students. Named to the United Nations Environment Programme's Global 500 Honor Roll in 1992, Earthwatch can be heard on 125 U.S. radio stations, the international Armed Forces Radio & Television Services network, and the "Earthwatch" Web site at <www.ewradio.org>.

■ Rhode Island Sea Grant pioneered the first U.S. program to train volunteers to sample and analyze water quality along the coast. In doing so, Sea Grant demonstrated that volunteers can not only provide accurate monitoring data, but the volunteers also become much better informed regarding the science and management of the coastal environment.

■ The National Ocean Science Bowl annually sees participation by 24 high-school teams who compete regionally before reaching the national stage. In addition to preparing bowl teams to answer rapid-fire questions about ocean and coastal science, Alaska's regional competition, hosted by Sea Grant, requires a research project. Over 200 students from coastal communities throughout the state (many inaccessible by road), have addressed important marine issues by researching the science, management, and socioeconomic factors involved. Students work as a team; interview local managers, users, and community leaders; and prepare both a research paper and oral presentation. Teams have gone on to give presentations in their communities, before local fish boards, and in one case, before a state legislative task force.



Research and Education Opportunities for Undergraduate and Graduate Students

SEA GRANT EDUCATORS ARE UNIQUELY POSITIONED TO...

... *Increase support for the continued development of innovative courses, research opportunities, and internship and fellowship programs for undergraduate and graduate students interested in marine and aquatic science-related professions.*

The education of future environmental professionals and leaders is critical to the responsible use and management of our nation's marine and aquatic resources. Science majors and future marine scientists need opportunities to learn science in real-world settings and to apply their skills at work under the mentorship of actual scientists.

Graduate students assist university marine and aquatic scientists on research aimed at addressing pressing issues ranging from harmful algal blooms to coastal erosion, or at developing new technologies, products from the sea, and improved coastal management strategies and policies. For undergraduates, such research opportunities are often an important introduction to marine science and policy and can serve as a catalyst for continued education leading to a marine career.

Inherent in this human resources development mandate is the need to reflect the nation's racial, ethnic, and gender diversity. Chronically low participation of African Americans and Hispanics in marine and aquatic science is a major problem; it is even more extreme than in other scientific disciplines. These trends must be arrested to ensure a diverse, technically competent workforce and the rights and responsibilities of all population groups to influence national ocean and coastal policies.

Sea Grant supports the professional development of undergraduate and graduate students interested in marine and aquatic science by providing hands-on research opportunities, by funding the development of innovative courses, and by offering internships and fellowship programs, including the nationally competed John A. Knauss Marine Policy Fellowships. However, all of these activities are severely limited because, with the exception of the Knauss Fellowships, they are inter-



▲ *Hands-on research opportunities for undergraduate and graduate students often serve as a catalyst for continued education leading to an environmental career.*

twined with the undercapitalized research base of the National Sea Grant College Program. Enormous opportunities exist to populate not just Congress, but business and industry and other governmental entities with knowledgeable marine and aquatic science professionals. Increased investment in human resources development with special attention to underrepresented population groups will help us take advantage of these opportunities.

SEA FACT: More than 50% of the entire U.S. population lives and works within 50 miles of the coastline.

■ The National Sea Grant College Program offers two competitive fellowships for exemplary graduate students interested in ocean, coastal, and Great Lakes resources. The John A. Knauss Marine Policy Fellowship, established in 1979, matches students with host agencies in the legislative and executive branches of the federal government in Washington, DC, for a year-long, paid fellowship. In the Sea Grant Industrial Fellows Program, created in 1995, students work collaboratively with a faculty adviser, Sea Grant program, and industry representative on a project, from beginning to end. Research facilities and costs are shared in this real-world collaboration designed to strengthen ties between academia and industry.

■ The complexity of future coastal issues demands that the best and brightest students learn to apply their talents to resolve coastal problems. North Carolina Sea Grant has established a fellowship program that will provide North Carolina graduate students the chance to spend a year working for Sea Grant on issues related to coastal policy and planning. Patterned after the National Sea Grant College Program's Knauss Fellowship, the North Carolina Program provides fellows with a \$25,000 annual stipend and invaluable experience. The program is open to graduate students at North Carolina colleges and universities, with preference given to environmental management, planning, or law students. Since the fellowship involves issues that bridge science and policy, students with technical skills in Geographic Information Systems are highly desirable.

■ Through contributions, grants, and local sponsorship, Texas Sea Grant recently added a marine education vessel to its marine education program. The 57-foot bay shrimp vessel *Karma* was converted to educational purposes and certified by the U.S. Coast Guard. So far, in its first two years of operation, the *Karma* and the Floating Classroom Program it supports, have served over 5,000 participants including students, teachers, community leaders, and Elderhostels.

■ Since 1986, Florida Sea Grant has helped 169 students complete their degrees from Florida universities as they worked on Sea Grant projects. Thirteen of these students are now working in federal jobs, with seven employed in the National Oceanic and Atmospheric Administration. At least one-quarter of Florida Sea Grant's federal research funds support graduate students working on a research project with a faculty adviser. About 20 graduate students per year are completing degrees with Florida Sea Grant support.



▲ Jeff Goodrich, an Earth science teacher at Lake Oswego High School in Oregon, was sponsored by Sea Grant to serve as the "teacher at sea" on a recent expedition aboard the NOAA vessel *Ron Brown* to an active underwater volcano.

■ The California Sea Grant Trainee Program provides graduate students with an invaluable opportunity to conduct research and receive training in disciplines related to marine resources while fulfilling thesis requirements. The students help implement Sea Grant-approved projects. Graduate Trainees, identified by project leaders, receive financial assistance in the form of monthly stipends through the project's duration. Since 1968, more than 900 traineeships have been awarded by California Sea Grant. Over the years, this program has created a major talent pool and fostered future generations of marine scientists, resource managers, and industrialists.



Curriculum Development

SEA GRANT EDUCATORS ARE UNIQUELY POSITIONED TO...

... *Continue producing high-quality, age-appropriate curricula that address emerging issues while incorporating the latest research and technologies available in the marine and aquatic sciences.*

Sea Grant educators have a long and successful history of developing and implementing high-quality marine and aquatic science curricula. This legacy began over 30 years ago and today includes many local, national, and international efforts that reach thousands of students each year.

Nationally, Sea Grant has earned a leadership position in developing marine and aquatic science curricula. This leadership is clearly documented through such successes as “Global Climate Change,” “Aquatic Exotics,” and “Careers in Marine Science.” Additionally, the “Coastal Management,” “Operation Pathfinder,” and “COAST: Pilot” regional courses continue to be very popular.

The 1999 Kellogg Commission Report, *The Future of the State Land-Grant Universities*, stresses that scientists must find paths for spreading their findings — paths that go beyond just the academic community. Sea Grant is positioned to help scientists share their research with the educational community, tailoring the information for kindergartners to Elderhostel participants. This report also urges educational institutions to enrich students’ experiences by bringing research and engagement into curricula and offering practical opportunities for students to prepare for the world they will enter as professionals.

As a federal-state-university partnership, Sea Grant helps forge strong working relationships between Sea Grant educators, university and NOAA scientists, and researchers in the social sciences (such as sociology, economics, and education). The resulting peer-reviewed curricula reflect the latest research, are typically interdisciplinary in scope, and are written with a sensitivity to grade-level appropriateness.

A typical Sea Grant curriculum offers “hands-on,” authentic science lessons, often including new technologies that incorporate real-time data obtained from satellites and offshore monitoring instruments. Sea Grant curricula, such as “Project Cool Classroom,” “Oceanography and Coastal Processes,” “NESDIS Remote Sensing from Satellites for Educators,” “Extreme Expeditions,” and various



▲ Students assemble Sea Grant’s 3-D horseshoe crab model in their science class.

on-line courses, bring a relevance to marine and aquatic science education that is not available through commercial publishers.

Additional means for the sustained distribution and infusion of curricular materials must be found. There are potential opportunities to interface with the NOAA Office of Ocean Exploration and the eventual federation of coastal observing systems, but such collaborations depend on reaching as many K–12 teachers throughout the nation as possible. Sea Grant’s vision is to build on past accomplishments and use existing strengths to develop new curricular materials that address emerging issues while incorporating the latest scientific knowledge and technology. However, the full potential of this vision will never be realized unless there is adequate funding to impact K–12 education in all 50 states.

SEA FACT: The blue whale — the largest animal that has ever lived (including dinosaurs) — has a heart the size of a small car.

■ The goal of the 2000–2002 Satellites and Ocean Science for Educators Workshops, funded by Sea Grant, the Science House at North Carolina State University, and NOAA's National Environmental Satellite, Data and Information Service (NESDIS), was to develop Web-based modules for middle- and high-school teachers and students that focused on the use of remote sensing technology to learn more about ocean processes and phenomena. Topics included coral bleaching, Gulf Stream currents, upwelling events, and harmful algal blooms. One of the workshops was conducted on-line.

■ The Mississippi-Alabama Sea Grant Consortium served as the lead institution for several professional teacher development programs that a number of Sea Grant programs have helped host during the past decade. The Operation Pathfinder,



▲ Sea Grant's "Zelda, the Zebra Mussel" makes her entrance at a Great Lakes teacher workshop on aquatic invasive species.

COAST (Consortium for Oceanographic Activities for Students and Teachers), and COAST: Pilot (Putting Interactive Learning on Target) institutes have provided educational programming in marine and aquatic science to over 700 pre-college teachers. These teachers have, in turn, impacted more than 14,000 "second-tier" teachers, who collectively have the potential, over just a five-year teaching career, of impacting more than 7.2 million pre-college students with information on oceanography and coastal processes. The institutes also resulted in the development of a popular instructional tool — *The Oceanography and Coastal Processes Resource Guide* — that was developed and field-tested "by teachers for teachers." The resource guide covers marine and aquatic habitats, plate tectonics, and other topics in 81 inquiry-based activities, all aligned with the *National Science Education Standards*. The guide is available on-line at <www.aquarium.usm.edu>.

■ The Exotic Species Day Camp Project and the ESCAPE *Collection of Classroom Activities* are the outcome of five Great Lakes Sea Grant Network training sessions involving several hundred classroom teachers and informal educators. ESCAPE, a collection of 36 hands-on, multidisciplinary activities, has enhanced existing programs in biology and environmental sciences. The inquiry-based lessons have helped students to understand the impact aquatic invasive species have on ecosystems and to explore potential solutions to these problems. ESCAPE has been recognized with three national awards, including the American Distance Education Consortium Outstanding Educational Program Award.



▲ A future teacher learns a lesson in fish anatomy in this hands-on curriculum.

■ Pennsylvania Sea Grant provides innovative hands-on environmental education programs to K–12 students and teachers utilizing on-the-water activities to teach important information about local environmental issues. The *Environmental Rediscoveries* curriculum is a unique resource for educators designed specifically to teach their students about the watersheds of Presque Isle Bay and Lake Erie. The curriculum complements field-based activities that allow students and teachers to directly interact with their local environment.



Inclusion of Traditionally Underrepresented/Underserved Groups

SEA GRANT EDUCATORS ARE UNIQUELY POSITIONED TO...

- ... *Develop and disseminate curricula and programs that are culturally relevant and bilingual.*
- ... *Partner with appropriate governmental and non-governmental organizations already embedded in communities to deliver programs targeted to a specific community's needs.*
- ... *Offer programs that provide resources and experiences of value to participants of all ages, from pre-kindergarten to high school, continuing to higher education and involving families.*

Demographic trends indicate that as the population of the United States continues to grow, it is becoming increasingly diverse, both culturally and ethnically. The *Milken Institute Report* (2000) noted that in the 2000 Census, "at least three out of ten U.S. residents will not be white Anglos. Before 2005, Hispanics will outnumber African Americans, and in the year 2030, one out of four Americans will be either Hispanic or Asian." As more people continue to migrate and settle in the coastal zone, the increasing population diversity of these areas will heighten the challenge of reaching all groups with marine and aquatic science education.

Underserved and underrepresented populations in marine and aquatic science may be identified as those groups (based on gender, race, or cultural ethnicity) to which access to marine and aquatic science has traditionally been severely limited. This situation may be due to any number of factors, ranging from peer pressure that discourages the pursuit of science, to stressful socioeconomic situations. Often members of underrepresented or underserved populations have never been to the beach or seen the ocean, even if they live within a few miles of the coast. Further, many do not have an understanding of how their actions can impact marine and aquatic environments.

Coastal areas with ethnically diverse populations and underserved groups should regularly be offered innovative marine and aquatic science education programs. People living in inland areas also need to be exposed to marine and aquatic science to encourage watershed stewardship.

Reaching the exploding numbers of underrepresented and underserved coastal constituents will continue to be a challenge to Sea Grant educa-

tors. Additional human and monetary resources are needed to help bridge existing cultural and ethnic barriers. Large numbers of immigrants from Southeast Asia and Spanish-speaking countries do not speak English. This language barrier could be overcome by creating more resources like the *Bilingual Coral Reef Resource Guide for Middle School Teachers and Students*. Whenever possible, Sea Grant programs should hire marine and aquatic educators who are familiar with a traditionally underserved or underrepresented group.

Another strategy would be to provide professional development workshops on coastal and freshwater issues to educators from targeted groups who agree to share the information with teachers in their locale. Further, teachers of targeted groups should be actively recruited to join local or regional chapters of the National Science Teachers Association or the National Marine Educators Association. Finally, the SGEN must continue to share its successes and strategies with other like-minded groups around the country in order to maximize efforts to reach traditionally underrepresented and underserved groups.



▲ Native American students in Washington State prepare for a Sea Grant research cruise.

■ Linking the emerging field of biotechnology with hands-on training in marine and aquatic science, Maryland Sea Grant has offered thousands of students, including many from the inner city, a unique opportunity at the world-class Center of Marine Biotechnology in Baltimore. At this facility, students are exposed to molecular biology, genetics, and an array of engaging marine topics, such as biofouling. The innovative program *Aquaculture in Action* (www.mdsg.umd.edu/Education/AinA) uses aquaculture as a basis for teaching a wide range of science topics and to show teachers how to build and operate fully functional aquaculture systems for their classrooms.

■ The *Bilingual Compilation of Coral Reef Activities for Middle School Teachers and Students* was produced in 1997 as a collaborative effort of the U.S. Environmental Protection Agency, U.S. Department of State, National Sea Grant College Program, Mississippi-Alabama Sea Grant Consortium, University of Southern Mississippi, and Puerto Rico Sea Grant. The National Geographic Society and the NOAA-Sustainable Seas Expedition also provided funding for aligning the guide with the *National Science Education Standards* and for reprinting the popular resource. The guide is available on-line at www.aquarium.usm.edu.

■ More than 45,000 Detroit-area students and adults have enjoyed learning about the Great Lakes, as well as their own role in protecting this freshwater ecosystem, while cruising on the Clinton and Detroit rivers and Lake St. Clair. Hands-on activities are a key element of the classroom and vessel-

based Great Lakes Education Program, begun in 1991 by Michigan Sea Grant and Michigan State University. Participation by under-represented populations is a major emphasis of the program. Approximately half the program participants are minorities, and well over half are female.

■ New Jersey Sea Grant, with funding from corporate partners, has “A Partnership for Learning” to bring marine and environmental science to under-resourced schools that primarily serve minorities. Another partnership enables underrepresented students to participate in a week-long marine science workshop at the New Jersey Marine Sciences Consortium, while “Project Grad” encourages minorities to continue their education past high school.

■ Southern California Sea Grant’s Parent Child Education Program (PCEP) is aimed at making basic science concepts approachable and fun for parent and child together as well as developing a sense of environmental stewardship, independent thinking, and creative expression through positive action. The PCEP is based at an inner-city school, and participants are primarily Latino and African American. As a team, parent and child attend a short course in



▲ Students get an up-close look at the marine world around them in a week-long Sea Grant workshop along the New Jersey coast.

marine/environmental science that focuses on the urban/ocean connection in regard to the Santa Monica Bay. Through the innovative PCEP learning process, the parent-child teams gain an elementary understanding of science and develop an increased regard and sense of responsibility relating to local environmental issues that impact the Santa Monica Bay. In addition to achieving a heightened awareness of environmental stewardship, the PCEP introduces effective communication techniques, initiates thoughts of new and exciting future career paths in the marine, health, or social science employment arenas, and fosters a lifelong interest in science and quality of self, family, and home.



Technology-Based Science Education

SEA GRANT EDUCATORS ARE UNIQUELY POSITIONED TO...

- ... *Provide teachers in classrooms throughout the nation with tools and strategies for involving their students in technology-based science discoveries.*
- ... *Continue to be national leaders in technology-based marine and aquatic science education as the possibilities rapidly evolve. Maintaining this lead will require support for additional professional development, the purchase and maintenance of up-to-date equipment, and a possible increase in technical support staff.*

Technology now makes communication possible on a scale that was unimaginable even a few years ago. Through the Internet, the majority of citizens in the United States have access to virtually unlimited information, training, and resources. According to the most recent National Center for Educational Statistics survey, 99% of K-12 public schools in the United States had access to the Internet as of fall 2001. Schools in high-poverty areas now lag behind the national averages for Internet access by only a few percentage points, suggesting that equity in access is steadily improving. Beyond the classroom, Americans are connecting to the Internet as part of their daily routine. Recent government surveys (Commerce Dept. 2001, 2002) indicate that 46% of all U.S. households (94 million individuals) were accessing the Internet on their home computers in 2000. By 2002, data revealed that 41.7% of employed U.S. adults used the Internet routinely at work.

The explosive growth, influence, and accessibility of the Internet has given Sea Grant educators unprecedented freedom and flexibility to design and disseminate marine and aquatic science education programs, and to expand beyond localized, site-specific efforts and offer comprehensive, collaborative programs that reach global audiences. Because computers and the Internet have become mainstream, Sea Grant educators now routinely publish their content-based resources on Web sites and CD-ROMs. Nearly every Sea Grant education program publishes on-line teaching resources and interactive materials for students.

Sea Grant educational exhibits are enhanced with computer simulations, touch-screen menus, and other interactive strategies that allow marine and aquatic research to intrigue diverse audiences. Professional development courses for educators are conducted on-line, creating a vibrant learning community among teachers, university faculty, and

scientists. Scientific expeditions are viewed in real-time in classrooms around the country. Students, teachers, and citizen volunteers perform long-term environmental monitoring, using computer technology and the Internet to store, analyze, and disseminate data.

Although the Internet and other distance-learning technologies may have created the most obvious change in Sea Grant education programs, the hands-on activities for which Sea Grant educators are renown have not been completely replaced by virtual experiences. Technology has allowed Sea Grant educators to involve students and teachers in field and laboratory activities that resemble the research practices of professional marine scientists. Field courses now incorporate not only traditional marine and aquatic science tools, such as seine nets, Secchi disks, buckets, and binoculars, but also digital water-quality testing equipment, hand-held GPS units, and laptop computers for data collection.

Perhaps the most important dimension of information technology is that it will enable the national Sea Grant network to reach an even broader audience with its excellent programs. States without Sea Grant programs will be better able to access marine and aquatic science learning experiences. An investment in packaging these educational programs for electronic distribution is required. The potential for multiplying the return on the existing investment unquestionably justifies increased support.



▲ Laptop computers are often standard equipment in today's marine and aquatic field experiences.

SEA FACT: In the past 200 years, 16 U.S. states have lost wetland areas greater than the size of Connecticut.

■ The Bridge (www.vims.edu/bridge), developed by Virginia Sea Grant, is a growing collection of the best marine education resources available on-line. Sponsored by the National Sea Grant College Program, the National Oceanographic Partnership Program, and the National Marine Educators Association, this nationally acclaimed Web site connects educators and researchers nationwide to over 1,000 peer-reviewed Web sites with current marine science content, research data, activities, and resources.

■ Delaware Sea Grant invites students and the public to dive into "Extreme Expeditions" (www.ocean.udel.edu/expeditions), a multimedia educational program developed in partnership with the National Science Foundation to explore hydrothermal vents over a mile deep in the Pacific Ocean. As University of Delaware marine scientists explore the vents, students follow along through journals, interviews, photos, and video clips that are uploaded daily to the program Web site. Students design experiments for the scientists to conduct at sea, and selected schools participate in a conference call with researchers working live on the seafloor in the submersible *Alvin*. Classrooms receive curricula, evaluations, resource guides, and an instructional video produced by WHY-TV (PBS). So far, the award-winning program has reached over 100,000 students in the United States and several foreign countries. It has been highlighted by the *New York Times* to National Public Radio and *Teacher Magazine*, and has received the National Science Teachers Association's SciLinks mark of excellence.

■ The JASON Project is an international, multi-disciplinary program that sparks the imagination of both students and teachers in fourth through ninth grade by inviting them to compare their local environment with remote locations in the world, where JASON scientists and researchers are conducting fieldwork. Wisconsin Sea Grant educators have developed Web sites (www.seagrants.wisc.edu) in support of the JASON Project, which feature cool science information on Great Lakes frogs, fishes, and birds, as well as marine topics such as underwater exploration.

■ Through a 10-year collaboration, New Hampshire Sea Grant and Woods Hole Oceanographic Institution Sea Grant have developed comprehensive information on marine science careers. The resulting Web site and publication help students of all ages and their parents, teachers, and guidance counselors explore career options available in the marine sciences. Both resources include overviews of marine biology, oceanography, and ocean engineering, as well as other related disciplines; question-and-answer profiles of dozens of men and women in those fields; and many additional resources. Over 40,000 copies of *Marine Science Careers* are in circulation. At the



▲ Through Sea Grant's on-line expeditions, youngsters and adults can explore the ocean from their computers.

Web site (www.marinecareers.net), hundreds of appreciative e-mails have been received from 49 U.S. states and 34 foreign countries.

■ Minnesota Sea Grant has been teaching high-school and community-college students basic science concepts through the use of real-time remote-sensing technology and Geographic Information Systems (GIS) software. Through the curriculum *Water on the Web* (waterontheweb.org), thousands of students have enjoyed using classroom computers connected to water-quality sampling "robots" located in lakes and rivers around the United States. Through this successful program, students can compare lake or river conditions in different eco-regions.



Assessment and Evaluation

SEA GRANT EDUCATORS ARE UNIQUELY POSITIONED TO...

- ... *Build assessment and evaluation expertise within the Sea Grant network and disseminate this expertise by example through existing programs and new programs specifically for assessment and evaluation training.*
- ... *Initiate projects that develop and refine appropriate assessment and evaluation strategies and practices for the marine and aquatic science education community.*
- ... *Enhance formal and informal education across the nation by building capacity in assessment and evaluation.*

It is evident that assessment and evaluation are becoming increasingly important and, in many cases, required components of most educational efforts. Currently, the skills and experience to conduct effective assessment and evaluation are not widely possessed by the SGEN. Opportunities to learn these skills and develop this expertise are limited, and an infrastructure providing continued assessment and evaluation support is needed.

While participation in marine and aquatic science education programs is increasing, documentation of cognitive and affective change in participants is difficult to measure, and long-term learning is even less frequently documented. With assessment and evaluation essential to the development and success of many programs, a continued financial investment is necessary to implement these procedures. Furthermore, there is a need to develop social laboratories to assess and evaluate the effectiveness of science-education strategies. Research on front-end analyses and formative and summative evaluation continues to demonstrate the advantages of these processes. However, additional research is required to develop evaluation strategies with results that can be generalized to other educational settings.

There are a number of locations in the Sea Grant network where evaluation training and research can be conducted. All Sea Grant programs are formally connected to universities or research institutions, and several Sea Grant programs already are engaged in formative and summa-



▲ As part of a Sea Grant workshop on coastal processes in Maine, teachers and field agents work together to take a beach profile.

...tive evaluation programs. Sea Grant educators regularly evaluate developing curricula, exhibits, and multimedia projects and assess learning and affective change in formal and informal programs. Plans and partnerships also are beginning to develop that will result in Sea Grant helping teachers to receive professional development in assessment and evaluation.

Assessment and evaluation efforts within the SGEN currently are isolated and mostly internal. However, that situation can change with additional coordination of expertise and partnerships, acquisition and development of educational resource materials, opportunities to participate in regional workshops, and recurring fiscal support. If these conditions are met, Sea Grant can continue to develop — within its ranks — a knowledgeable and experienced corps of marine and aquatic science educators who can capably practice assessment and evaluation. These men and women could then positively impact all aspects of Sea Grant programming. Due to Sea Grant's many program connections, there is every expectation that professional development in the field of assessment and evaluation, as well as other support activities, can be extended even further to broaden internal and external network capabilities.

SEA FACT: U.S. coastal watershed counties contribute \$5 trillion to the nation's economy — that's one-half the Gross Domestic Product.

■ *The Life of the Lakes: The Great Lakes Fishery*, an award-winning set of educational materials, was developed and produced by Michigan Sea Grant in cooperation with the Great Lakes Sea Grant Network. Hundreds of fourth-grade through college-level educators and resource professionals have used the materials, which have met the rigorous educational standards of the American Fisheries Society Education Committee and have ranked well in evaluative research conducted for the Great Lakes Fishery Trust.

■ It is often difficult to detect change among students when their teachers have been involved in Sea Grant workshops, but an article in the North American Association for Environmental Education's *NAAEE Monograph* details an important example of such success. Middle-school teacher teams from the Cleveland region participated in Sea Grant's interdisciplinary courses for Great Lakes education, then taught their students, and presented open-house programs using their knowledge. Middle-school student scores on course topics increased by 28% in life sciences, 21% on environmental issues, 17% on Earth science topics, and 9% on climate and the Great Lakes.

■ A graduate student at Ohio State University developed her master's thesis around an assessment of how Sea Grant's student workshops at F. T. Stone Laboratory on Lake Erie affected the science attitudes of sixth-graders. Her research

indicated that the Stone Lab experience was associated with significant positive changes in general science feelings and reports of the value of science among participants. Stone Laboratory is the oldest freshwater biological field station and research lab in the United States. Its workshop program provides hands-on experience in aquatic ecology for student groups (fourth grade and up) in both the spring and fall. The program accommodates over 6,000 participants every year from Ohio and neighboring states.

■ South Carolina Sea Grant funded a research study in 1997–1998 that compared a traditional model of instruction with a model designed to change student conceptions or misconceptions. This study was conducted in marine science courses for marine science majors and non-science majors. Qualitative and quantitative methods were used to determine cognitive and affective change in these students. Change in graduate instructor perceptions of their teaching was also assessed. Data supported improved learning and attitudes



▲ Students ponder the water resource questions, developed by Sea Grant, at the National Science Olympiad.

using the conceptual change model (CCM). In addition, the graduate students preferred the CCM and believed their teaching was improved.

■ In an effort to improve assessment and evaluation capabilities in the SGEN, 22 members participated in a three-day assessment and evaluation workshop in April 2003. Topics included assessment and evaluation strategies, approaches, and methodologies, and how to determine which approach is best in a given situation based on the strengths of a specific method. A variety of methods were tested in the field to provide a basis for group comparison. This was a first step; more professional development opportunities in assessment and evaluation are desired and needed.



Fostering Collaborations and Partnerships

SEA GRANT EDUCATORS ARE UNIQUELY POSITIONED TO...

- ... *Capitalize on partnering opportunities with a variety of collaborators and partners.*
- ... *Ensure that partnerships and collaborations result in the maximum of positive impacts for target audiences.*
- ... *Increase their participation in fruitful collaborations and partnerships with additional resources to support these efforts.*

Sea Grant marine and aquatic science education activities are founded in, and increasingly require, collaborations and partnerships with other entities having similar goals. These collaborations and partnerships are necessary due to limited resources and personnel, but they also reflect a desire to include the wide range of stakeholders concerned about marine and aquatic science literacy.

Collaborations and partnerships fostered across the SGEN include the teaming of people from professional organizations, institutions, or agencies to multiply the efforts of professional staff for programs. A partnership might involve a public facility, such as an aquarium, museum, or environmental science center, that serves as the location of a program or exhibit hosted jointly by Sea Grant and that facility's educators. Or a collaboration between Sea Grant informal educators and television stations, radio stations, and other broadcast media in the development of joint productions that enable Sea Grant to extend marine and aquatic science information to millions.

Of course, many partnerships benefit greatly by sharing expenses and submitting joint proposals. Examples of large programs founded in partnership include Operation Pathfinder, conducted by the Mississippi-Alabama Sea Grant Consortium, with local, regional, and national partnerships; and North Carolina's Coastal Heritage Program, in which faculty from three universities provided science and education concepts through summer professional development programs.

Collaboration and partnership are increasingly valued and expected by federal agencies that fund science-education reform activities. It is



▲ The artist Wyland leads a mural painting activity at the University of Delaware's Coast Day. The educational festival, hosted by Sea Grant and the College of Marine Studies, teaches over 10,000 visitors each year about coastal resources.

clear that no one organization can have the same impact as many who are working in partnership. It is critical that Sea Grant programs support these collaborating and partnering efforts by also bringing something to the table. Too often, the Sea Grant educator has few real dollars available to support these efforts. Their contributions are primarily in-kind, setting up an inequality among partners from the beginning. It is very important that sufficient funds be made available to allow Sea Grant to fully participate in these efforts.

SEA FACT: The world's longest bony fish — the serpent-like oarfish — can grow to 50 feet long.



SEA GRANT'S RECORD OF SUCCESS

■ Sea Grant is a major partner in the Central Coordination Office and in five of seven regional Centers of Ocean Sciences Education Excellence (COSEE), recently funded by the National Science Foundation with support from the National Oceanic and Atmospheric Administration, the Office of Naval Research, and the National Oceanographic Partnership Program. These centers will serve as catalysts and points of contact for educators and researchers interested in improving and expanding ocean science education around the country.

■ For over three years, Maine Sea Grant has been involved in the Cobscook Bay current-monitoring study, a collaboration with Texas A&M University, the Cobscook Bay Resource Center, and students and teachers at Shead High School in Eastport. Drifting devices, released at various points in the bay, track currents. Data entered into a computer model reveal how water is circulating and pinpoint locations where nutrients or pollutants are likely to be deposited. The project has its



▲ *In partnership with the City of Honolulu, Sea Grant is teaching the public about the importance of the state's coral reefs.*

own Web site and has produced maps of the bay's circulation that are being used by finfish aquaculture operators in choosing new sites.

■ For more than 35 years, Oregon Sea Grant has partnered with the Hatfield Marine Science Center in Newport, offering marine science education to nearly 150,000 visitors to the exhibit hall and over 10,000 students annually. The students participate in a variety of school-based and day camp programs that offer hands-on field investigations that range from sandy beach and estuarine studies to animal adaptation activities.

■ Working with the Governor's Office, Delaware Sea Grant established the Governor's Marine Science Teacher-of-the-Year Award in 2001. The goal of the award program is to recognize, on an annual basis, an outstanding Delaware teacher with a strong commitment to marine and aquatic science education. Among the honors, the winner receives an all expenses-paid trip to the National Marine Educators Association conference, the largest assembly of marine and aquatic science educators in the world.

■ Over the last 15 years, Mississippi-Alabama Sea Grant has partnered with the J. L. Scott Marine Education Center and Aquarium, administered by the University of Southern Mississippi, in funding its award-winning Project Marine Discovery Programs. Docents



▲ *Lifelong learners prepare for a kayaking expedition led by Sea Grant educators.*

at the Scott Aquarium can take credit for the success of these informal, interpretive programs in science education. Their efforts range from week-long summer camps to on-the-road programs serving pre-schoolers, families, and underserved/underrepresented schools. The heavily visited programs (31,000 pre-college students and teachers annually) currently are self-sustaining.

■ Partnering with the City of Honolulu, Hawaii Sea Grant has begun providing information on coral-reef ecology, snorkeling, and SCUBA diving etiquette for the more than one million visitors who come to swim and snorkel in Hanauma Bay, Oahu, each year. Aimed at mitigating damage to the coral reef by visitors, this program also fosters a sense of stewardship. The program's success has prompted the city to build a state-of-the-art interpretation center to enhance education about Hawaii's coral reefs.

Benefits to the Nation

“... What science education will be in any one year for any one child is most dependent on what that teacher knows, does, and believes . . . or doesn't know, doesn't do, or doesn't believe, for the teacher is the enabler, the inspiration, or the constraint for this nation's students.”

— National Science Foundation, 1978

If these eight objectives for the Sea Grant Education Network are achieved, the United States will benefit in myriad ways, including the following:

- ◆ *Enhanced marine and aquatic science literacy* — essential for a nation that has the fourth longest coastline in the world.
- ◆ *Informed environmental decision-making* — critical when over 50% of the U.S. population now lives along the coast.
- ◆ *Improved public safety* — through increased awareness of marine and aquatic issues and phenomena, from harmful algae to rip currents.
- ◆ *Greater appreciation and stewardship* — of the water resources that make our “blue planet” the living planet.
- ◆ *And ultimately, a diverse, more technologically skilled workforce* — well-equipped to address the challenges of the 21st century.

Marine and aquatic science literacy is critical to the future of the United States, to both the nation's human resources and its marine and aquatic resources. ▶



SEA FACT: The ocean is our “life-support system” — besides weather, food, jobs, and products, it provides over 70% of the oxygen we breathe.

Envisioning the Future

In view of the eight objectives set forth in this document, it is anticipated that over time, more comprehensive and focused funding for the Sea Grant Education Network will result in a significant increase in public knowledge and understanding of the scientific processes and issues related to marine and aquatic areas. As the network is better able to fund and strengthen its local efforts, its zeal and expertise in marine and aquatic science education will powerfully complement many ongoing and emerging federal efforts. In addition, a highly educated and diverse workforce attuned to the sciences and issues pertinent to marine and aquatic areas will emerge.

Sea Grant's vision for U.S. education is ambitious, focused, and proactive: to remain a world leader, the United States must develop well-prepared professionals who understand and are conversant in marine and aquatic science and research issues. To achieve this vision, this nation has a "long way to go" in producing both an informed citizenry — one that is environmentally and scientifically literate — and a cadre of technical, policy, and managerial professionals who can ensure a sustainable future.



▲ *The ocean is Earth's largest natural resource and its final frontier for human exploration.*

Sea Grant, by Congressional mandate, is in the education business and has the expertise, but not the funding, to support a national education base. This leadership role is becoming increasingly more important as the need and demand for marine and aquatic science education intensifies.

As a national network, Sea Grant has the inherent strengths necessary to be a key player in the development of this critical national education base. For nearly four decades, strong regional infrastructures have been developed and maintained only as the result of leveraging other funding

sources. Because of Sea Grant's minimal investment in formal and informal marine and aquatic science education, the Sea Grant network has worked to meet this national need by developing additional funding relationships. The consequence of this funding strategy is the alignment of Sea Grant educational objectives with those of other funding partners involved. It is time for Sea Grant to fulfill its education mandate by increasing its investment in formal and informal education programs, thus assuming the leadership role the National Sea Grant College Program should provide.

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NOAA/Sea Grant, R/SG
1315 East-West Highway
SSMC-3, Eleventh Floor
Silver Spring, MD 20910-3226
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URL: <http://www.seagrants.noaa.gov>

Alaska Sea Grant College Program
University of Alaska Fairbanks
P.O. Box 755040
Fairbanks, AK 99775-5040
Phone: (907) 474-7949
URL: <http://www.uaf.edu/seagrant>

California Sea Grant College Program
University of California, San Diego
9500 Gilman Drive
La Jolla, CA 92093-0232
Phone: (858) 534-4440
URL: <http://www.csge.ucsd.edu>

Southern California Sea Grant Program
University of Southern California
3616 Trousdale Parkway - AHF 209
Los Angeles, CA 90089-0373
Phone: (213) 740-1961
URL: <http://www.usc.edu/org/seagrant>

Connecticut Sea Grant College Program
University of Connecticut
1080 Shennecossett Road
Groton, CT 06340-6097
Phone: (860) 405-9128
URL: <http://www.seagrants.uconn.edu>



Delaware Sea Grant College Program
University of Delaware
Graduate College of Marine Studies
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URL: <http://www.ocean.udel.edu/seagrant>

Florida Sea Grant College Program
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P.O. Box 110400
Gainesville, FL 32611-0400
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URL: <http://www.flseagrant.org>

Georgia Sea Grant College Program
University of Georgia
Marine Sciences Building, Room 220
Athens, GA 30602-3636
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URL: <http://www.marsci.uga.edu/gaseagrant>

Hawaii Sea Grant College Program
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Phone: (808) 956-7031
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Illinois-Indiana Sea Grant College Program
University of Illinois
1101 W. Peabody Drive
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Urbana, IL 61801
Phone: (217) 333-6444
URL: <http://www.iisgcp.org>

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317 Aiken Center, School of Natural Resources
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Phone: (225) 578-1558
URL: <http://www.laseagrant.org>

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University of Maine
5715 Coburn Hall
Orono, ME 04469-5715
Phone: (207) 581-1422
URL: <http://www.seagrants.umaine.edu>

Maryland Sea Grant College Program
University System of Maryland
4321 Hartwick Road, Suite 300
College Park, MD 20740
Phone: (301) 403-4220
URL: <http://www.mdsg.umd.edu>

Massachusetts Sea Grant College Program
Massachusetts Institute of Technology
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New Jersey Marine Sciences Consortium
Sandy Hook Field Station
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New York Sea Grant Institute
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Virginia Graduate Marine Science Consortium
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